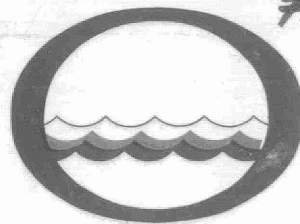


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SLUDGE THICKENING

IN

PRIMARY CLARIFIERS



THE ONTARIO WATER RESOURCES COMMISSION

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SLUDGE THICKENING IN PRIMARY CLARIFIERS

Little River WPCP

By:

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September, 1967

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SLUDGE THICKENING IN PRIMARY CLARIFIERS

Little River WPCP

1.0 INTRODUCTION

1.1 Reason for Study

The Little River WPCP in Windsor, Ontario has a sludge handling method unique to sewage treatment plants in Ontario. The two primary settling tanks are designed each with a central drop section to which settled sludge is moved by a raking mechanism. The sludge is thickened and stored in the drop section and subsequently drawn off by sludge pumps for treatment and disposal. The structure of the primary tanks eliminates the necessity of building special sludge thickening units since the drop section performs the same function.

Since this design of primary settling tank is unique to Ontario and since it effects a substantial saving in initial and operating plant costs, it was decided that a detailed study of the performance of the process was warranted.

1.2 Scope of Study

The scope of this study has been limited to the performance of the primary settling tanks in respect to both suspended solids and BOD reductions and to sludge thickening. Twenty-four hour composite samples of raw sewage and primary effluent were taken over a one week period from May 29 to June 2, 1967. Grab samples of waste sludge and draw-off sludge were taken when the respective pumps were in operation. Draw-off sludge refers to that taken from the primary holding tanks.

Because of the relatively low flows during this study, a visit to the plant was also made on June 13, following a period of heavy rains. This enabled a comparison of plant operation at the two flow levels.

2.0 WASTE SLUDGE TREATMENT METHODS

There are several sludge treatment methods in use in Ontario all with the one purpose of achieving as high a solids concentration as is practical. Both the primary sludge and the secondary sludge must be disposed of by as economical a process as possible. Primary sludge is composed of those solids which settle out of the raw sewage in primary settling tanks while secondary sludge is waste activated sludge generally obtained from the secondary settling tanks.

Excess activated sludge generally contains from 98.5 to 99.8% water, which makes it very voluminous. Thus, some method of concentration is usually a necessary prerequisite regardless of the disposal method.

Where excess activated sludge is to be digested, it is quite common practice to pump it back to the primary settling tank and allow its solids to settle out with the heavier raw solids. This practice reduces the volume of sludge to be digested, but often causes operational difficulties.

As an alternative, separate sludge-thickening tanks are sometimes used. This involves the construction of

center-feed, radial-flow sedimentation tanks with circumferential outlet weirs and sludge collection mechanisms. In some instances the thickener inflow is drawn directly from the aeration tanks while, in other cases, it may be waste sludge drawn from the final clarifiers. In either event it is found desirable to maintain a rate of inflow as uniform as possible throughout the day and as low as is compatible with wasting the necessary amount of solids. It is also found desirable to withdraw thickened sludge practically continuously at such a rate as to maintain a constant sludge blanket level.

Primary settling tanks designed with a central drop section as used at the Little River WPCP eliminate the necessity of designing special sludge thickening tanks. The sludge drawn off from such a tank is of denser composition than most digested sludges. Since the drop section may also be used as a sludge holding tank, sludge does not have to be drawn-off continuously and withdrawal times can be co-ordinated with the operation of the plant.

3.0 PLANT PROCESS DESCRIPTION

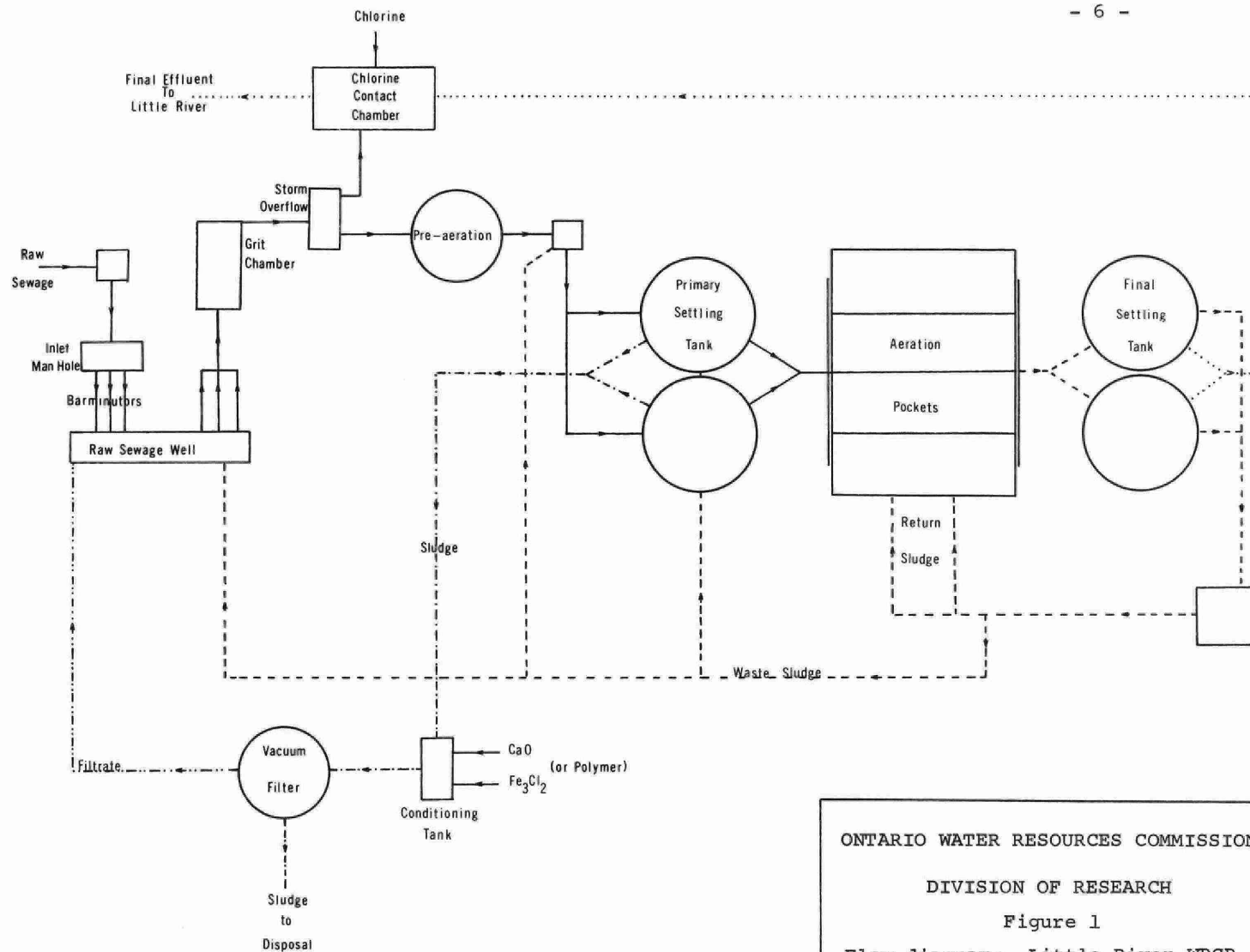
2.1 General

The Little River WPCP was officially opened on December 1, 1965, but has been in operation since midsummer of that year. It is to provide secondary treatment, using the activated sludge process, for a dry weather flow of 4 million gallons (Imp) per day. At the time of this study the plant was operating under a load of approximately 1.6 MGD, less than 50% design load, varying from 2.4 to 0.9 MGD. During periods of rain, flows to the plant may exceed 10 MGD for short durations and 5 MGD for longer periods.

Figure 1 presents a schematic flow diagram of the plant.

2.2 Primary Treatment

Primary treatment facilities consist of a Rotogrator and coarse bar screens followed by an elevated grit chamber to allow for gravity flow to the remainder of the treatment process. Storm overflow weirs allow a maximum of 8 MGD to pass through the plant and the bypassed storm sewage flows to a cell of the chlorine contact chamber. Although facilities have been provided for preaeration, they were not being used at the time of this study.



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Figure 1

Flow diagram: Little River WPCP

September, 1967

The primary settling tanks are specially constructed to allow thickening and storage of sludge, thus eliminating the necessity for special sludge thickening tanks. Although sludge has been stored for as long as a 7 day period, the storage time is generally not greater than 2 to 3 days.

2.3 Secondary Treatment

Secondary treatment is provided for by four aeration tanks, three of which were in operation during the study. Aeration is provided by four surface aerators per tank, for a 6 hour period. These are followed by final settling tanks of 3 hour design detention. Up to 100% of the activated sludge may be returned.

2.4 Sludge Treatment and Disposal

The combined raw and waste activated sludges are withdrawn from the drop section of the primary settling tanks and piped through glass-lined cast iron pipes to the sludge conditioning tanks. Lime and ferric chloride are added in such amounts to give values of 2.3 and 8% by weight, respectively, to the filter vat. After vacuum separation, the liquid is discharged to the wet well and the solids are fed to a hopper for disposal to a sanitary land fill.

During this study a polymer, instead of the standard lime and ferric chloride coagulants, was being used for sludge conditioning. Since the use of polymers for sludge conditioning is still a relatively new concept, it was used here on an experimental basis.

2.5 Operation of Primaries

The two primary settling tanks are operated in parallel. Flow entering the plant is divided equally with one-half the flow entering each primary. Wasted sludge from the secondary settling tanks is returned to the primaries by injection into the holding tanks. Generally the sludge is wasted at 10 to 20% of the sludge return rate; this being approximately equivalent to 6% of the dry weather flow. Thickened sludge is drawn off first from one holding tank and then the other for an average period of five hours per day for five days per week. The sludge withdrawal period depends upon the density of the draw-off sludge as determined by a sludge density meter, with sludge generally not being wasted at below 4% solids. The vacuum filtrate is discharged to the wet well and recycled with the raw sewage.

4.0 STUDY METHOD

Since this was a study of the operation and efficiency of the primary settling tanks, all sampling was centered around these units.

Twenty-four hour composite samples were taken of the influent and effluent, while grab samples were taken of waste activated sludge, draw-off sludge and vacuum filtrate. A continuous recording of draw-off sludge density was taken with a density meter. At the time of the study an aqueous injection of chlorine was being made upstream from the meter and therefore grab samples were taken before the chlorine injection to obtain the true density of the draw-off sludge.

The composite samples were subjected to analyses for BOD, suspended solids (SS), volatile suspended solids (VSS) and total and soluble phosphorus. Samples of waste sludge, draw-off sludge and vacuum filtrate were submitted for total and volatile solids determinations. All analyses were made according to "Standard Methods".

Flow measurements were made of influent, waste activated sludge and draw-off sludge. It was assumed that the effluent volume was equal to that of the influent.

5.0 OPERATIONAL PROBLEMS AT TIME OF STUDY

Several operational problems were being experienced at the time of the study. The plant was receiving intermittent shock loadings of a glue or similar substance which caused a bulkiness to the mixed liquor for an indefinite period of time. Because of the bulky nature of the mixed liquor, poor settling was effected by the secondaries and any sludge wasted to the primaries was of a very light composition.

Also at the time of the study an organic polymer was being experimented with as a coagulant aid for sludge conditioning. Although the polymer has several distinct advantages over the use of the conventional conditioners, a very rigid control must be maintained on the addition of the polymer in relation to the composition of the sludge. Perhaps because of the type of feed pump being used, the plant was unable to maintain an adequate control on polymer injection. As a result, and also due to the bulky nature of the sludge, a poor sludge cake was established on the filter. This led to a high carry-over of solids in the filtrate, aggravating the bulky condition of the aeration mixed liquor.

6.0 OBSERVATIONS AND DATA

A discussion of the difficulties in plant operation at the time of the study has been presented in the previous section. Thus, it is only necessary here to say that the plant was operating much more properly during the June 13 visit although difficulties were still being experienced with the use of the polymer.

Table 1 presents maximum, minimum and average values of data collected for the period May 29 to June 2, 1967.

Table 2 gives the data collected on June 13, 1967.

The influent to the primary was sampled behind the point where the vacuum filtrate was injected. Therefore, the influent sample contained both raw sewage and vacuum filtrate when the filter was in operation. In spite of the high solids level of the filtrate (4,000 ppm total solids), however, it only contributed approximately 2% of the influent suspended solids.

Influent

	Flow (MGD)	BOD (ppm)	SS (ppm)	VSS (ppm)
Max.	2.4	138	448	352
Min.	0.9	124	220	140
Avg.	1.6	134	293	202

Effluent

	Flow (MGD)	BOD (ppm)	SS (ppm)	VSS (ppm)
Max.	2.4	83	120	96
Min.	0.9	72	46	39
Avg.	1.6	75	75	63

Waste Activated Sludge

	SS (ppm)	VSS (ppm)
Max.	4620	3710
Min.	2860	1964
Avg.	3580	2522

Draw-off Sludge*

	T.S. (%)	V.S. (%)
Max.	7.7	67
Min.	3.5	63
Avg.	5.6	65

* T.S. - total solid percent by weight

V.S. - percent volatile by weight of total solids

TABLE 1 - Summary of Collected Data, May 29 to June 2, 1967

	Time	Total Solids (%)	Volatile Solids (% of Total)
Primary #1			
	8:00 a. m.	9.8	51
	8:30 a. m.	9.7	54
	9:00 a. m.	9.4	55
	9:30 a. m.	9.3	59
	10:00 a. m.	9.3	60
	10:30 a. m.	9.2	51
Primary #2			
	11:00 a. m.	11.1	42
	11:30 a. m.	10.9	46
	12:00 noon	10.5	38
	1:00 p. m.	10.4	46
	1:30 p. m.	10.2	48
	2:00 p. m.	10.2	59

TABLE 2 - Primary Draw-Off Sludge Solids - June 13, 1967

7.0 DISCUSSION OF DATA

A close examination of the primary settling tank data indicates a high level of performance. BOD and suspended solids reductions are in the order of 50 and 75%, respectively. Draw-off sludge from the holding tanks range from 5% solids by weight at periods of low flow to 10% at periods of high flow. The difference at the two flow rates apparently being due to the higher concentrations of silt and other inert settleable solids at times of high flow. The volatile percentages of the draw-off sludges were 65 and 47% respectively, for the two flows. It appears that due to the low gradient of the sewer mains, solids settle out in them at periods of low flow, only to be carried on at high flows.

The density of the draw-off sludge drops off very slowly with pumping time until, as indicated by chart recordings made by the sludge density meter, a sudden drop in density occurs after about five hours pumping. Thus it appears that although there may be 6 to 7 feet of sludge in the holding tank it is all of relatively the same density, and the holding tank may be virtually emptied of sludge at each pumping.

8.0 CONCLUSIONS

The use of a central drop section in the primary clarifier such as that employed at the Little River WPCP can be an effective unit for sludge thickening prior to vacuum filtration. Sludge densities in the order of 8 to 10% or higher may be achieved. With proper operation and loading of the plant, densities should not drop below 5%.

High BOD and SS reductions in the order of 50 and 75%, respectively, may be achieved by this design of clarifier.

The primary clarifier lends itself to complete automation. With an automatic control, sludge withdrawal pumps can be set to cut off at a predetermined minimum sludge density. If desired the sludge withdrawal schedule may be set to comply with other plant processes as it is not necessary to pump the sludge continuously. Sludge may be held in the tank during weekends requiring no filtering or sludge haulage at such times.

Even though difficulties in plant operation were being experienced due to the shock loads of glue and experimentation with the polymer, the sludge produced from the drop section of the primary clarifier was of density equal to that of ordinary digester sludge. At periods of normal operation and high flows, sludge densities of 10% or over may be achieved.



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